From:	Nilkanth Chapole
Sent:	14 November 2022 15:49
To:	'bimal@qsutra.com'
Cc:	mts@qsutra.com; mx@qsuta.com
Subject:	RE: Technical query on how Minitab generates Covariance matrix used for Generalized Variance Chart (with no subgroups exist, subgroup size=1)

Thanks Bimal!
Appreciate your time to respond.
And this solves my query.

Yes, you have provided formula before.
I was more lean on following excerpt from generalize variance formula page from Minitab support document, when no subgroup.

> If no subgroups exist, all formulas for the Generalized Variance chart cannot be calculated. In th
> Minitab standardizes all values by subtracting the appropriate column mean and then dividing l
> square root of the appropriate variance from the covariance matrix of all the data.

And, had attempted accordingly.

While the Key was difference in subsequent values, as no subgroup.

I would like to attend training on multivariate data and or Control charts using Minitab by Qsutra.
Request to share any future announcements related to these topics.

Thanks!

Regards,
Nilkanth

From: bimal@qsutra.com <bimal@qsutra.com>
Sent: 14 November 2022 12:44
To: Nilkanth Chapole <Nilkanth.Chapole@granulesindia.com>
Cc: mts@qsutra.com; mx@qsuta.com
Subject: RE: Technical query on how Minitab generates Covariance matrix used for Generalized Variance Chart (with no subgroups exist, subgroup size=1)

CAUTION: External Domain Email !! Do not click links or open attachments unless you recognize the sender and know the content is safe..
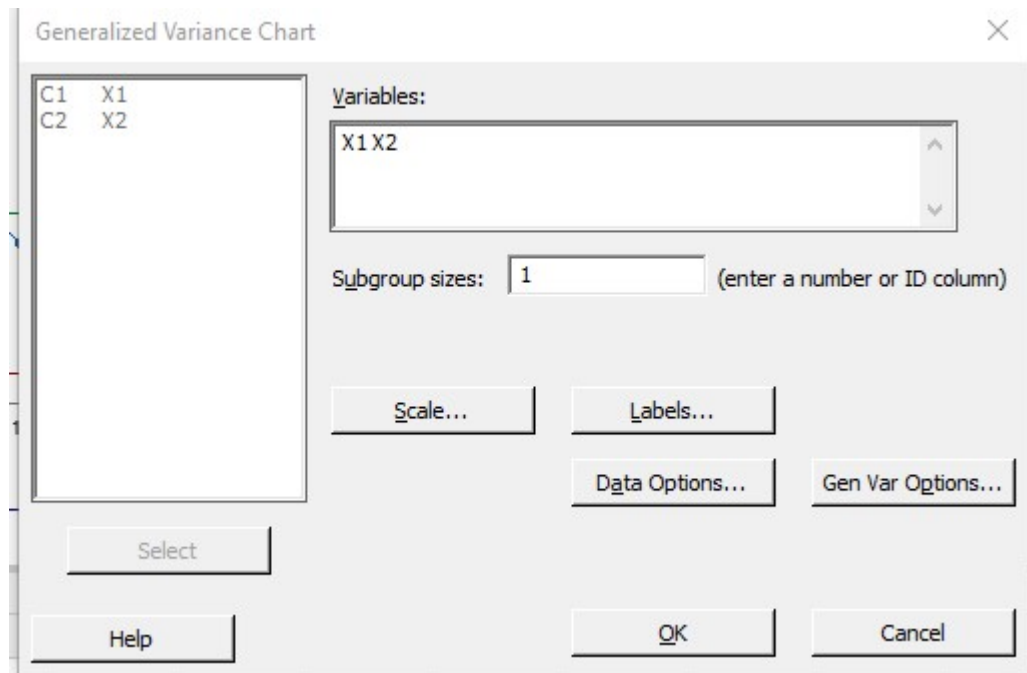
Dear Nilkanth,

Thank you for your mail!

Regarding your question:
- How can You get the covariance matrix as that of used for generalize variance chart?

This can be stored in the worksheet, I explained that to you in the example.
Go to Stat > Control Charts > Multivariate Charts > Generalized Variance
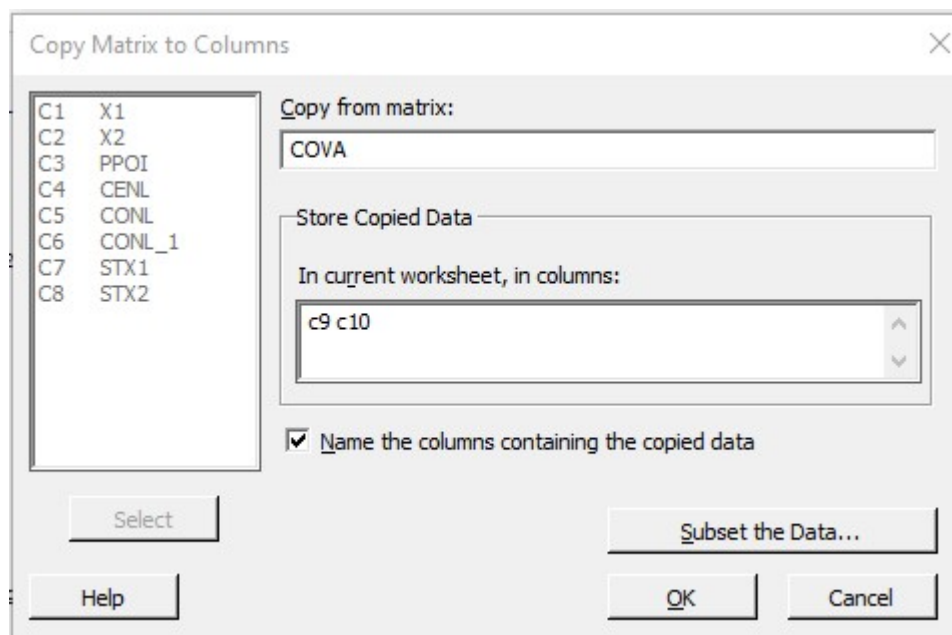
Put the values as shown here:

Click on Gen Var Options

Click on Storage

Choose Covariance Matrices

1. **Show the Covariance Matrix you obtain from the control chart when generating it and copy it to columns c9 c10.**
   Go to Data > Copy > Matrix to Column do as follows

Click Ok

- **Way Minitab generates it?**

Minitab uses the formulas here: (which we already shared with you)

$$S = \frac{1}{2(m-1)} \sum_{i=1}^{m-1} v_i v_i$$

where:

$$v_i = x_{i+1} - x_i$$

And m is the number of samples.

Here is an example, on how to calculate this by hand, then you can verify it.

Let's go back to my data.

X1	X2
12.78	31.2881
14.97	38.1993
15.43	38.8387
14.95	37.4431
16.17	41.4101
17.25	43.3266
16.57	39.6343
19.31	48.0613
18.75	48.3875
16.99	43.4925
18.20	44.2329
16.20	40.9430
14.72	35.2621
11.02	28.9415

Put that in Minitab

C1	C2	C3
X1	X2	
12.78	31.2881	
14.97	38.1993	
15.43	38.8387	
14.95	37.4431	
16.17	41.4101	
17.25	43.3266	
16.57	39.6343	
19.31	48.0613	
18.75	48.3875	
16.99	43.4925	
18.20	44.2329	
16.20	40.9430	
14.72	35.2621	
11.02	28.9415	

Now, let's take the successive differences for X1 and X2 and store them on C3 and C4.
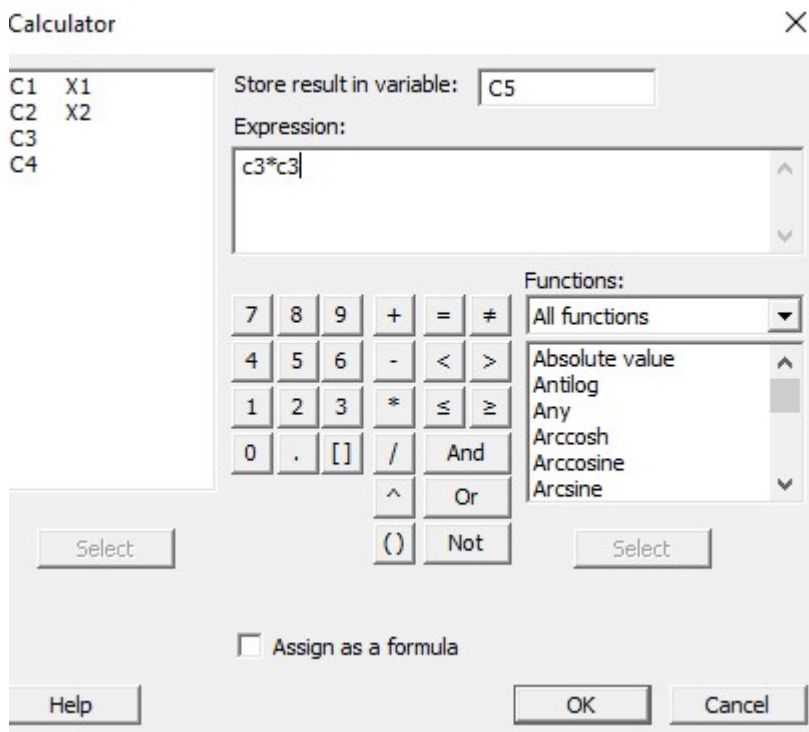
Go to Stat > Time Series > Differences
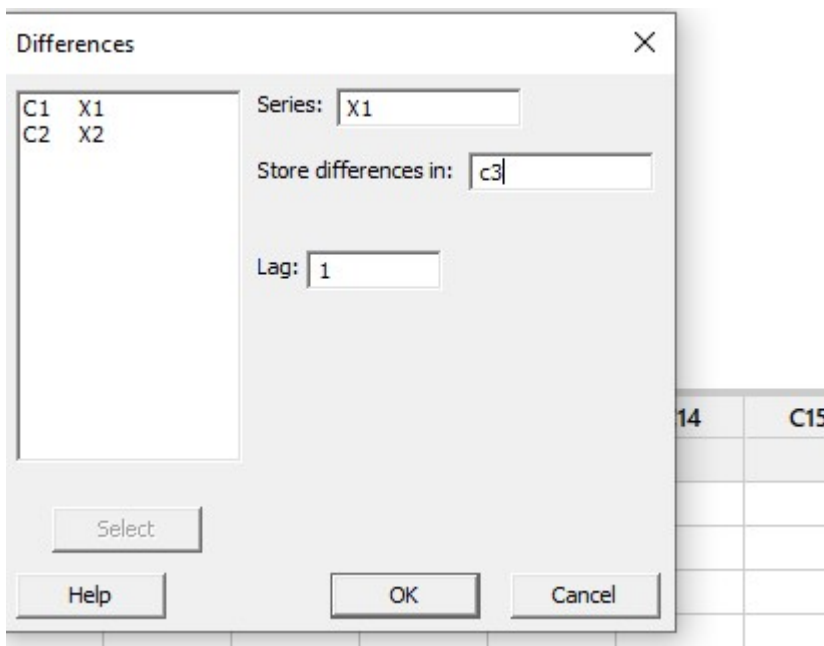
Do the same for X2 and store it on C4.

The result is as follows:

C1	C2	C3	C4	C5	C6
X1	X2				
12.78	31.2881	*	*		
14.97	38.1993	2.19	6.9112		
15.43	38.8387	0.46	0.6394		
14.95	37.4431	-0.48	-1.3956		
16.17	41.4101	1.22	3.9670		
17.25	43.3266	1.08	1.9165		
16.57	39.6343	-0.68	-3.6923		
19.31	48.0613	2.74	8.4270		
18.75	48.3875	-0.56	0.3262		
16.99	43.4925	-1.76	-4.8950		
18.20	44.2329	1.21	0.7404		
16.20	40.9430	-2.00	-3.2899		
14.72	35.2621	-1.48	-5.6809		
11.02	28.9415	-3.70	-6.3206		

Create three more columns. C3*C3, C4*C4 and C3*C4

Go to Calc > Calculator to do that.

Calculator ✕

C1 X1
C2 X2
C3
C4

Store result in variable: C5

Expression:

c3*c3

Functions:

| 7 | 8 | 9 | + | = | ≠ | All functions ▼ |

4	5	6	-	<	>	Absolute value
1	2	3	*	≤	≥	Antilog / Any
0	.	[]	/	And		Arccosh / Arccosine
			^	Or		Arcsine
			()	Not		Select

☐ Assign as a formula

Help   OK   Cancel

The rest is easy so not going to put it here.

Go to Stat > Basic Stat and do a sum of all the new variables and store them.

Store Descriptive Statistics ✕

C1 X1
C2 X2
C3
C4
C5 C3*c3
C6 C4*c4
C7 c3*c4

Variables:

'C3*c3'-'c3*c4'

By variables (optional):

Select

Statistics...   Options...

Help   OK   Cancel

	C7	C8				C14	C15	C16	C17
	c3*c4								
*	*								
7	15.1355								
B	0.2941								
7	0.6699								
1	4.8397								
D	2.0698								
1	2.5108								
B	23.0900								
4	-0.1827								
D	8.6152								
2	0.8959								
4	6.5798								
5	8.4077								
D	23.3862								

So far, this is your worksheet.

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
X1	X2			C3*c3	C4*c4	c3*c4	Sum1	Sum2	Sum3	
12.78	31.2881	*	*	*	*	*	40.6186	261.840	96.3120	
14.97	38.1993	2.19	6.9112	4.7961	47.7647	15.1355				
15.43	38.8387	0.46	0.6394	0.2116	0.4088	0.2941				
14.95	37.4431	-0.48	-1.3956	0.2304	1.9477	0.6699				
16.17	41.4101	1.22	3.9670	1.4884	15.7371	4.8397				
17.25	43.3266	1.08	1.9165	1.1664	3.6730	2.0698				
16.57	39.6343	-0.68	-3.6923	0.4624	13.6331	2.5108				
19.31	48.0613	2.74	8.4270	7.5076	71.0143	23.0900				
18.75	48.3875	-0.56	0.3262	0.3136	0.1064	-0.1827				
16.99	43.4925	-1.76	-4.8950	3.0976	23.9610	8.6152				
18.20	44.2329	1.21	0.7404	1.4641	0.5482	0.8959				
16.20	40.9430	-2.00	-3.2899	4.0000	10.8234	6.5798				
14.72	35.2621	-1.48	-5.6809	2.1904	32.2726	8.4077				
11.02	28.9415	-3.70	-6.3206	13.6900	39.9500	23.3862				

Now if you divide Sum1 by 2*(m-1) where m=14 then you must divide all of them by 26. I did that and stored the results in c11 c12 c13.

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
X1	X2			C3*c3	C4*c4	c3*c4	Sum1	Sum2	Sum3	
12.78	31.2881	*	*	*	*	*	40.6186	261.840	96.3120	1.56225
14.97	38.1993	2.19	6.9112	4.7961	47.7647	15.1355				
15.43	38.8387	0.46	0.6394	0.2116	0.4088	0.2941				
14.95	37.4431	-0.48	-1.3956	0.2304	1.9477	0.6699				
16.17	41.4101	1.22	3.9670	1.4884	15.7371	4.8397				
17.25	43.3266	1.08	1.9165	1.1664	3.6730	2.0698				
16.57	39.6343	-0.68	-3.6923	0.4624	13.6331	2.5108				
19.31	48.0613	2.74	8.4270	7.5076	71.0143	23.0900				
18.75	48.3875	-0.56	0.3262	0.3136	0.1064	-0.1827				
16.99	43.4925	-1.76	-4.8950	3.0976	23.9610	8.6152				
18.20	44.2329	1.21	0.7404	1.4641	0.5482	0.8959				
16.20	40.9430	-2.00	-3.2899	4.0000	10.8234	6.5798				
14.72	35.2621	-1.48	-5.6809	2.1904	32.2726	8.4077				
11.02	28.9415	-3.70	-6.3206	13.6900	39.9500	23.3862				

Now you can just type it like a matrix.

C11 = S1,
C12 = S2,
And C13 is covariance between X1 and X2.

This should suffice.

Please let us know if you need further assistance

Best Regards
Bimal

Dear Bimal,
Prior to this query, I had referred to earlier solutions by technical team, email attachment you shared.

However, It does not solved my query on understand how Minitab generates the covariance matrix used in generalized variance chart,
It had provided understanding on next part of, how generalized variance values are generated for each observations.

Request to demonstrate with simple calculations as you demonstrated earlier, using stat and basic calculation formula in Minitab,
Such that covariance matrix generated is same as that of covariance matrix by using generalized variance chart.
My attempts to generate the same had been shared in 1st query mail, refer to trailing mails.

I shall be using Minitab for multivariate control charts training for the company associates, and
It is imperative to understand the covariance matrix by generalize variance chart.

I shall arrange a call if you need more clarity on query.

Thanks!

Regards,
Nilkanth

> CAUTION: External Domain Email !! Do not click links or open attachments unless you recognize the sender and know the content is safe..

Dear Nilkanth,

Thank you for your mail!

Please find the attached mail for your reference and share more details on your below query / challenge (specially on below highlighted portion) so that we can be able to help you better.

Your Query :
How do I get covariance matrix as that of used for generalize variance chart.
The method/formula/way Minitab generates it?

Best Regards
Bimal

From: Nilkanth Chapole <Nilkanth.Chapole@granulesindia.com>
Sent: 10 November 2022 18:04
To: bimal@qsutra.com
Cc: mts@qsutra.com; mx@qsuta.com
Subject: RE: Technical query on how Minitab generates Covariance matrix used for Generalized Variance Chart (with no subgroups exist, subgroup size=1)

Dear Bimal,
I had referred to shared links,
Following is excerpt from generalize variance formula page from Minitab support document, when no subgroup.

If no subgroups exist, all formulas for the Generalized Variance chart cannot be
Minitab standardizes all values by subtracting the appropriate column mean an
square root of the appropriate variance from the covariance matrix of all the da

Minitab support document does not contain what I was looking for.

Query is simple,
How do I get covariance matrix as that of used for generalize variance chart.
The method/formula/way Minitab generates it?

Appreciate your time to respond.

Thanks!

Regards,
Nilkanth

From: bimal@qsutra.com <bimal@qsutra.com>
Sent: 10 November 2022 17:47
To: Nilkanth Chapole <Nilkanth.Chapole@granulesindia.com>
Cc: mts@qsutra.com; mx@qsuta.com
Subject: RE: Technical query on how Minitab generates Covariance matrix used for Generalized Variance Chart (with no subgroups exist, subgroup size=1)

Dear Nilkanth,

Thank you for your mail!

Please find the generalized variance chart link below might be helpful.
-   Here for Overview for Generalized Variance Chart in Minitab 21
-   Here for Example of Generalized Variance Chart with data, Steps, and Interpretation
-   Here for Methods and Formulas Minitab use for Generalized Variance Chart.

Best Regards
Bimal

From: Nilkanth Chapole <Nilkanth.Chapole@granulesindia.com>
Sent: 10 November 2022 11:59
To: mts@qsutra.com
Subject: Technical query on how Minitab generates Covariance matrix used for Generalized Variance Chart (with no subgroups exist, subgroup size=1)

Dear Minitab Technical Team,

As we know, generalized variance chart is used to monitor variance in multivariate data.
It is also known that the Generalized variance value for observation is based on Covariance matrix of the data.

I was trying to understand, how Minitab generates Covariance matrix used for Generalized Variance Chart (with no subgroups exist, subgroup size=1)
Table below contains data used to get covariance matrix.

X1	X2
12.78	31.29
14.97	38.20
15.43	38.84
14.95	37.44
16.17	41.41
17.25	43.33
16.57	39.63
19.31	48.06
18.75	48.39
16.99	43.49
18.20	44.23
16.20	40.94
14.72	35.26

11.02	28.94

Below is Covariance matrix using generalized variance chart (subgroup size=1)

COVA_1	COVA_2
1.56225	3.7043
3.70431	10.0708

I had compared covariance matrix obtained using generalized variance chart with
1. Covariance matrix using as is data (Minitab Navigation: Stats > Basic Statistics > Covariance).

COVA1_1	COVA1_2
5.0428	12.4046
12.4046	31.6362

2. Covariance matrix on data standardized by "Subtract Mean and divide by Std.dev"
   (Minitab Navigation for Standardization: Calc > Standardize)
   (Minitab Navigation for covariance matrix: Stats > Basic Statistics > Covariance).

COVA2_1	COVA2_2
1.00000	0.98210
0.98210	1.00000

3. Covariance matrix on data standardized by "Subtract Mean"
   (Minitab Navigation for Standardization: Calc > Standardize)
   (Minitab Navigation for covariance matrix: Stats > Basic Statistics > Covariance).

COVA_3_1	COVA_3_2
0.309798	0.293277
0.293277	0.318331

4. Covariance matrix on data standardized by "divide by Std.dev"
   (Minitab Navigation for Standardization: Calc > Standardize)
   (Minitab Navigation for covariance matrix: Stats > Basic Statistics > Covariance).

COVA4_1	COVA4_2
1.00000	0.98210
0.98210	1.00000

Observation is,
covariance matrix considered for generalized variance chart with subgroup size=1 is not same as covariance matrix on as is data or covariance matrix on standardized data.
(Minitab file attached for information)

Please help to understand how Minitab generates Covariance matrix used for Generalized Variance Chart (with no subgroups exist, subgroup size=1).

Thanks!

Regards,
Nilkanth
AGM-Corporate Quality.
Granules India Ltd.
Hyderabad.